BRUSH

OPERATING INSTRUCTIONS

Recorder Mark II
Model RD 2521 20

MP MASTER
MA34683

Recorder Mark II
Model RD 2521 20

WARRANTY

Each instrument manufactured by Brush Instruments, Division of Clevite Corporation, is warranted to be free from defects in material and workmanship and to operate in accordance with the published specifications when used with the recommended Brush associate equipment and with Brush chart paper. Liability under this warranty is limited to servicing or adjusting any instrument returned to a factory branch service station for that purpose and to replacing any defective parts thereof except tubes, fuses, and batteries.

This warranty is effective for one year after delivery to the original purchaser. When the instrument is returned tansportation charges are to be prepaid by the original purchaser. If defective operation has been caused by misuse or abnormal conditions of operation, repairs will be billed at our current rate. In this case an estimate will be submitted before work is started.

SUPPLIES AND SERVICE

Brush Instruments factory branch offices and service stations:

East

BOSTON
Brush Instruments
New England District Office
Factory Sales & Service
Northwest Industrial Park
Burlington, Massachusetts
Phone: Browning 2-0750

WASHINGTON
Brush Instruments
Washington District Office
Factory Sales & Service
6715 Kenilworth Ave.
Riverdale, Maryland
Phone: Union 4-0057

Mid-West

CLEVELAND
Brush Instruments
Midwest District Office
Factory Sales & Service
37th and Perkins
Cleveland 14, Ohio
Phone: Endicott 1-3315

West

DENVER
Brush Instruments
Denver District Office
300 Speer Boulevard
Denver 3, Colorado
Phone: 744-2371

LOS ANGELES
Brush Instruments
Western Regional Office
Factory Sales & Service
1960 So. LaCienega Blvd.
Los Angeles 34, California
Phone: Upton 0-7517

SAN FRANCISCO
Brush Instruments
District Office, 61 Renato Court
Redwood City, California
Phone: Emerson 9-5581

general information

Recorder Mark II
Model RD 2521 10

The Brush Recorder Mark II provides immediately visible, permanent chart recordings on two channels over a wide amplitude and frequency range (d.c. to 100 cps). The Recorder includes oscillograph and amplifiers as an integral unit which is operated from any a.c. outlet through one power cord.

The Recorder is designed for a minimum of operator adjustments, with three simple controls per channel, and self-cleaning, self-priming pens. Pushbuttons permit instant selection of chart speeds (1, 5, 25, and 125 mm/sec.).

Other features are fast, front-loading change of chart paper, unitized components, and a slide-out chassis for quick inspection.

Extreme stability and high sensitivity are featured in the Recorder; a 10 millivolt input signal produces a pen deflection of one chart line (mm).

specifications

Sensitivity	10 millivolts per chart line (mm). Full scale deflection from chart center ± 200 millivolts.
Sensitivity Steps	.01, .02, .05, .1, .2, .5, 1, 2, 5, and 10 volts per chart line (mm). Maximum attenuator error 1% with balanced input.
Measurement Range	
Single-ended Input (5 Megohm)	.010 volt to 400 volts.
Balanced Input (10 Megohm)	.010 volt to 400 volts, side to side, allowable voltage off-ground at any attenuator step is 1000 x volts per chart line switch setting up to 500 volts off-ground.
Common Mode Rejection	Better than 1000 to 1, attenuator set in .01 volt per chart line position.
Zero Line Stability	Less than 1/10 chart line (mm) per hour. Total drift over eight hour period not more than 1/4 chart line (mm).
Noise	Not noticeable on chart with shorted input.
Pen Bias	Permits positioning of pen on chart ± 20 chart lines (mm). Effective for either single-ended or balanced input.

Frequency Response	The recorded peak-to-peak amplitude of a constant voltage sine wave will be within ± 1 chart line (mm) of a nominal 10 lines from d.c. to 100 cps.
Maximum Amplitude	40 lines (mm) peak-to-peak, d.c. to 40 cps. 20 lines (mm) peak-to-peak, d.c. to 70 cps. 10 lines (mm) peak-to-peak d.c. to 100 cps.
Trace Linearity	DC within 1% full chart width. AC within 2% full chart width, any frequency within limits of maximum amplitude for ink writing.
Trace Width	0.015" with Model RA 2821 31 pen.
Writing Method	Ink.
Number of Recording Channels	Two
Number of Event Channel s	Two, actuated by external switch. In addition the left event marker may be actuated by switch on front panel.
Channel Width	40 mm (40 divisions).
Chart Speeds	1, 5, 25, and 125 mm per second.
Chart Supply	300 feet long x 3.718" wide. Model RA 2921 32.
Chart Speed Regulation	Synchronous motor, direct drive.

Operating Temperature Range, Ambient	0° C to 55° C.
Power Requirements	115-230 volts
Tubes	1-6BW4, 2-12B4A, 4-12AT7, 4-12AX7, 1-5651 and 4-5687.
Input Terminals	
Front (Signal)	Binding posts.
Rear (Event Marker)	Binding posts.
Dimensions	12-5/8" wide x 12" high x 13-1/2" deep.
Net Weight	32 pounds.
Shipping Weight	38 pounds.
Ventilation	Fan ventilated, through rear panel.

operating supplies

For peak performance and the best in recorded charts, use only Brush Engineering Chart Paper, supplies and parts to equip and maintain your Brush Mark II Recorder:

DESCRIPTION	BRUSH PART NO.
Chart Paper...Ink...2-Channel...300 feet long	RA 2921 32
Ink...Red...2 oz...in Mark II Ink Reservoir	RA 2761 02
Pens...Ink (4)	RA 2821 31
Syringe Assembly	125160-501
Gram Gage Assembly	227418-910

operation

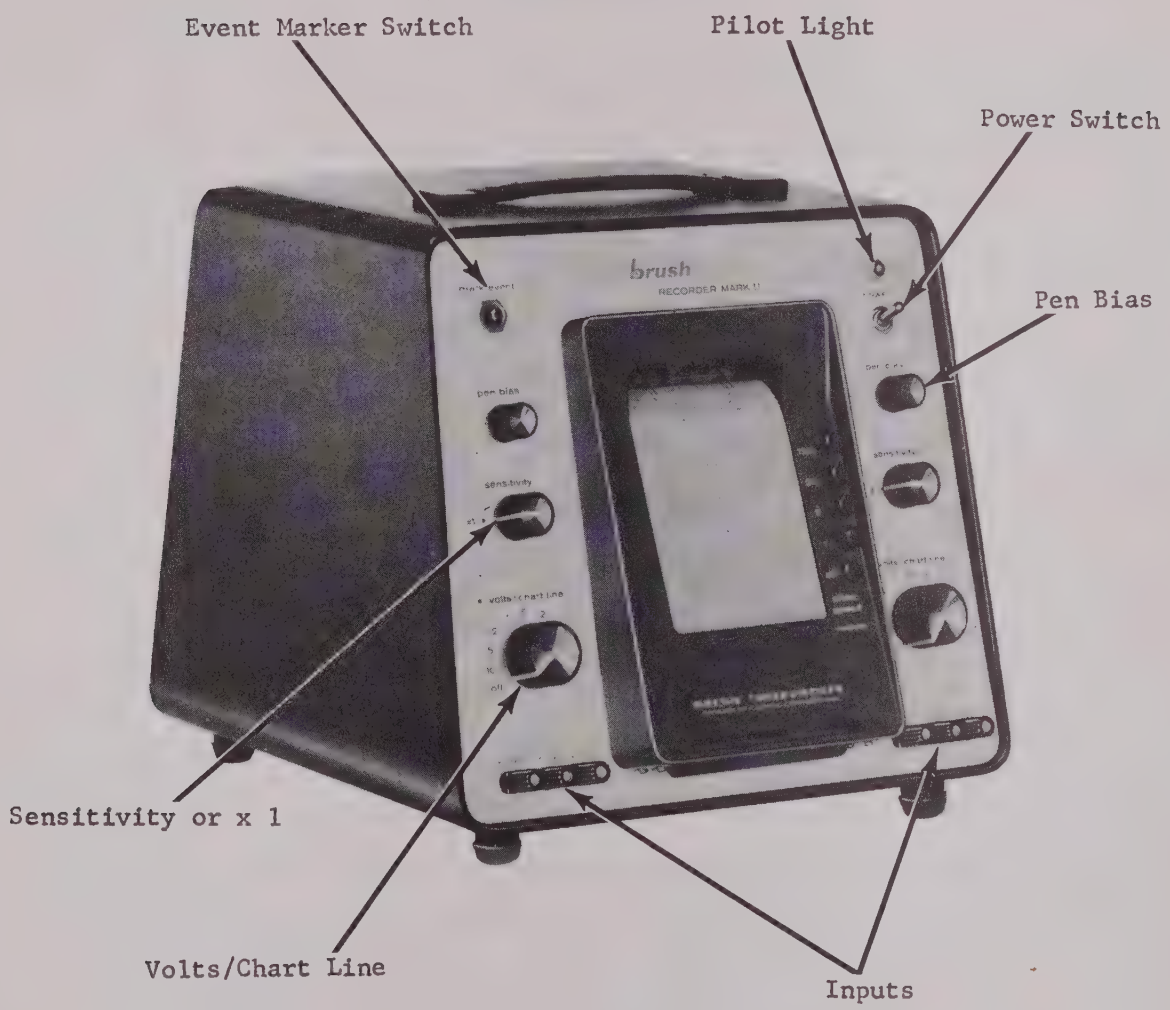


Figure 1. Controls, Front Panel

operation

(See Figure 1)

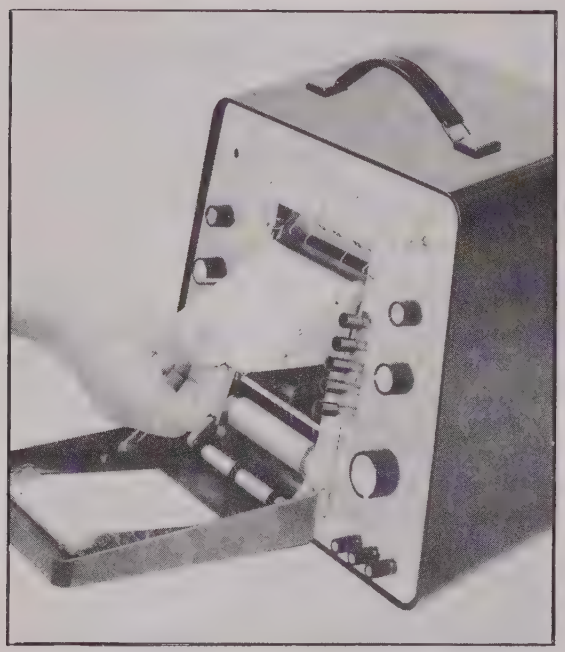
1. Connect power cable to power source. Turn POWER switch "on", depress chart speed "off" button and allow Recorder to warm up for 15 minutes.
2. Turn VOLTS/CHART LINE switches "off", depress CHART SPEED "5" button, and bring pen to chart center (or other desired position) with PEN BIAS control. To stop Recorder, depress CHART SPEED "off" button.
3. Connect input signal to INPUT"1" and "2" terminals. For single-ended input, connect GROUND AND INPUT "1" terminals with ground strap. For balanced (double-ended) input, move ground strap.
4. Turn SENSITIVITY control counterclockwise until a switch is actuated at "X1" position. Depress CHART SPEED button for desired speed, and set VOLTS/CHART LINE switch in desired position.

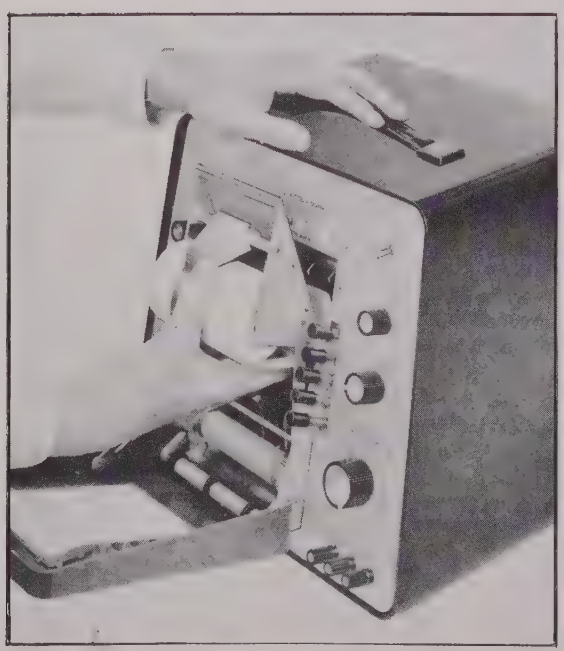
   When sensitivity control is in "X1" position, recorded signal is equal to product of pen deflection in chart lines (mm) times VOLTS/CHART LINE switch setting. This position of SENSITIVITY control adjust sensitivityof amplifier so that value of recorded signal is read directly as the product of pen deflection and VOLTS/CHART LINE switch setting.

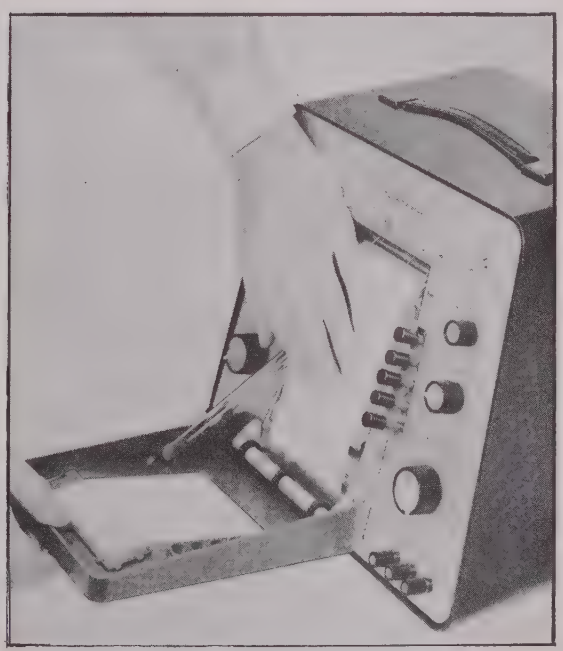
   If other sensitivity values are desired, or if external calibration is used, SENSITIVITY control may be turned clockwise from"X1" position until desired pen deflection is obtained.

event markers

Power for Event Markers is supplied internally from a 24 volt d.c. supply; events are recorded by closure of external switches. Connections for Event Markers are made through EVENT terminals on rear of Recorder. Panel switch, momentary contact actuates left event marker; switch parallels external circuit connections.







Loading Chart Paper

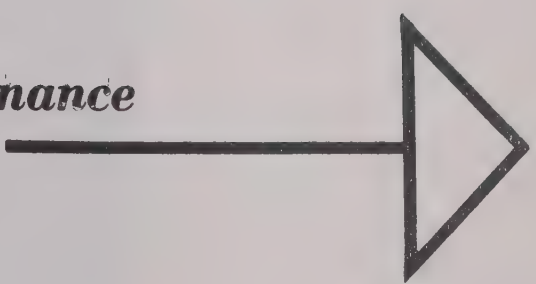
TO LOAD CHART PAPER (See Figure 2

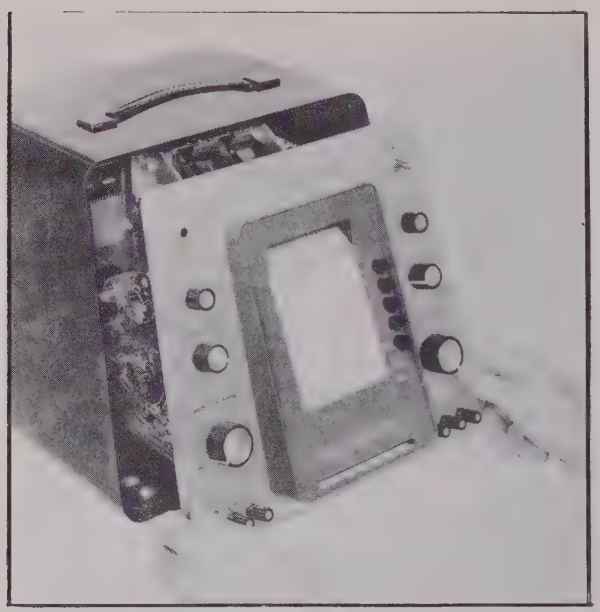
1. Pull front door outward and downward to limit. Pull writing table outward and upward to limit (1). Lift paper tension arm and remove paper supply shaft.
2. Insert paper supply shaft in paper supply. Lift paper tension arm and position paper supply shaft in slots on writing table side plates, with about 4" of paper rolling downward (2). Replace paper tension arm on paper supply and remove all slack from behind tension arm. Feed chart paper up over writing table and pull paper to end of table (3).
3. Return writing table to operating position, place end of chart paper between drive roll and tension roll (4), then return front door to operating position, place end of chart paper between drive roll for a few seconds at 125 mm/sec. to align chart paper on writing table.

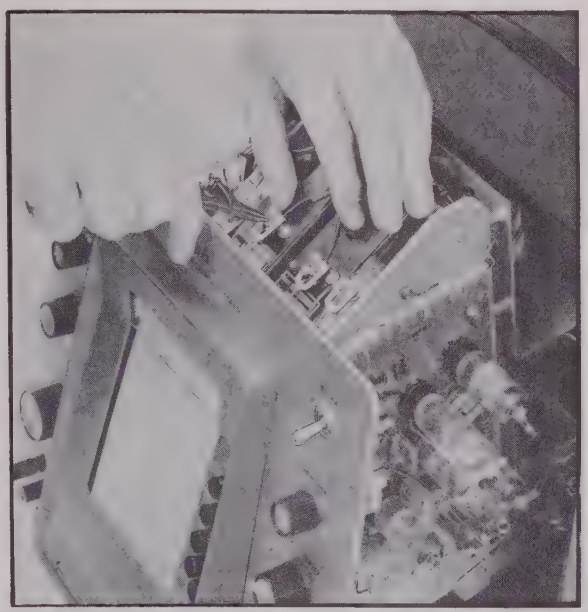
to change ink reservoir

1. Remove rear door.
2. Lift reservoir from clamp and unscrew reservoir from cover (1)
3. Remove cover from replacement reservoir and screw replacement reservoir securely into cover in the recorder.
4. Place reservoir in clamp, and close rear door.
5. Open front door and press primer buttons until ink flows from all pens (2).
6. Close front door.

maintenance







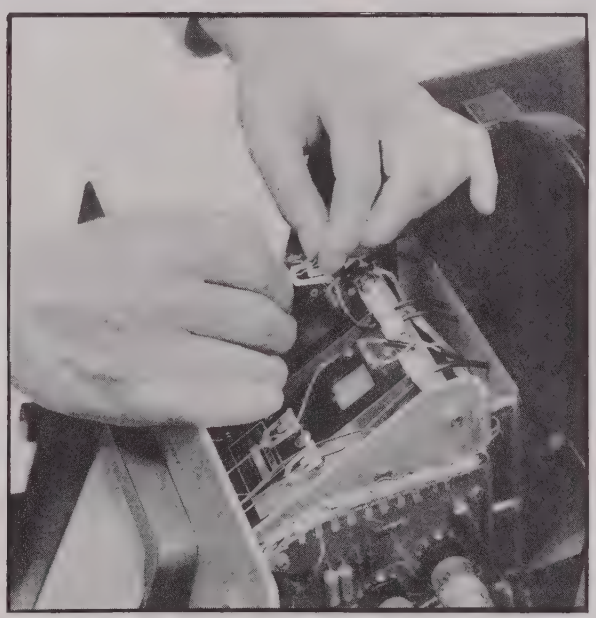


Figure 4. Changing Pens

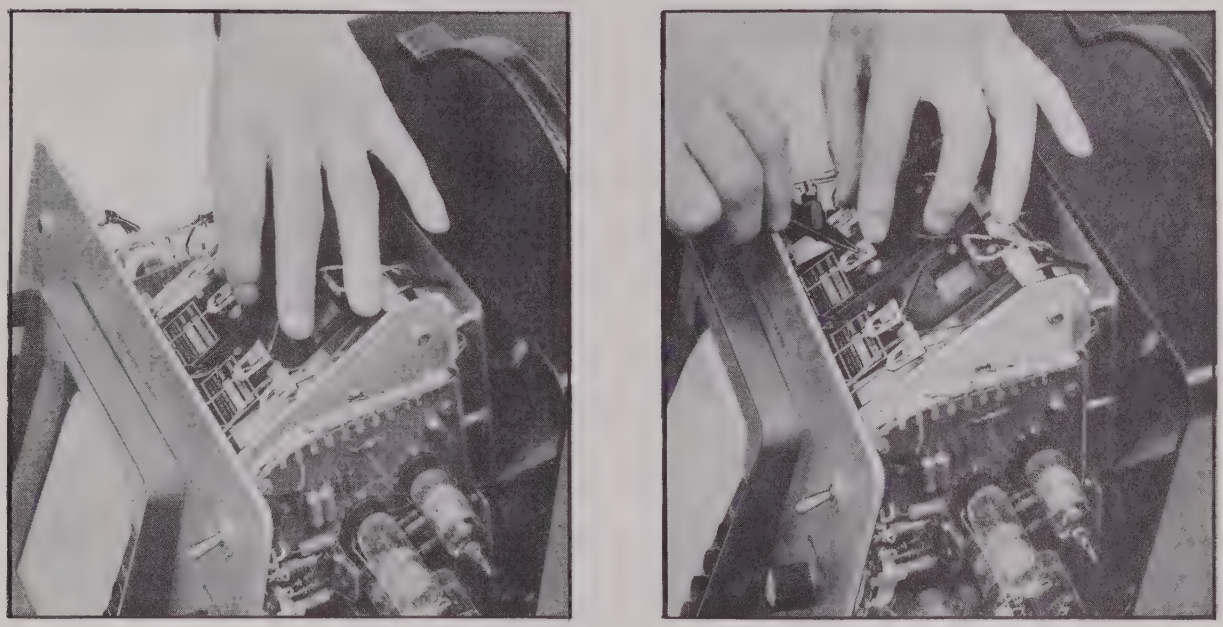


Figure 4. Changing Pens

pens

Procedure below must be followed for proper operation of Recorder. To prevent damage to penholder or upper bearing of penmotor, do not force penholder from vertical position or spread grooved sides excessively.

to remove pens

1. Loosen knurled screws securing Recorder in case (1) and slide Recorder from case (2).
2. Spread penholder slightly with Pen Mounting Tool, and pull tongue of pen from penholder (3). Disconnect capillary tube from pen(4).

TO MOUNT PENS

1. Connect capillary tube to pen (4). Position yoke of pen over penholder, aligning tongue of pen with grooves in penholder (5). Spread penholder slightly with Pen Mounting Tool and press tongue of pen as far as possible into penholder (6).
2. If one signal pen tip is farther forward than the other (both pens seated in penholders), draw longer pen back until pen tips are aligned. Align Event Marker pen tips with intersection points of outer printed lines on chart and curved paths of signal pen tips. Press primer button until ink flows, return Recorder to case, and secure with knurled screws.

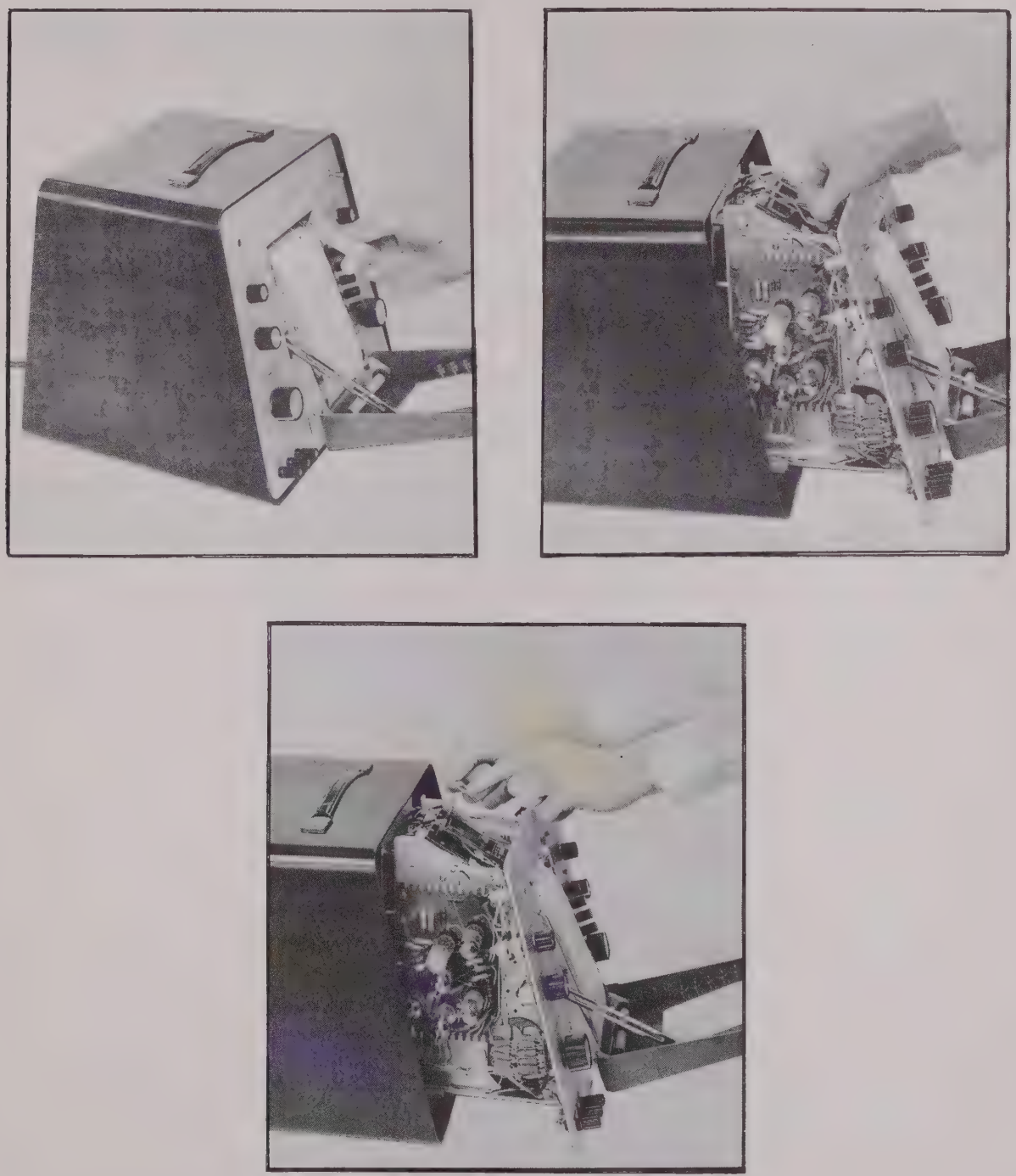


Figure 5. Adjusting Pens

to adjust pen pressure

For Optimum writing from d.c. to 100 cps., pen tip should apply from .5 to .75 gram pressure to chart paper. If most recordings will be made at frequencies from d.c. to 10 cps., with maximum amplitude of 10 mm peak-to-peak, a pen pressure of .35 gram is recommended. If most recordings will be made at frequencies from 10 to 100 cps., a pen pressure of 1.25 grams may be used.

Pen pressure is measured by placing hook of Gram Gage under pen 1/32" behind pen tip; reading is taken just as pen tip is lifted from paper (1).

1. If pen pressure is too great, lift pen tip from paper a few times (exerting upward pressure on penyoke) until correct gage reading is obtained (2).
2. If pen pressure is too low, remove pen from penholder and bend tongue upward slightly in relation to yoke. Mount pen and measure pen pressure. Repeat adjustment until correct pressure is obtained (3).

ink system

A completely enclosed ink system is used on the Recorder; this prevents foreign material from entering the ink system, and prevents excessive evaporation of ink. However, for optimum performance, the cleaning procedures described below should be followed after every 3 months of operation.

Figure 6. Cleaning Pen

to clean ink pens

The pen tip is tapered inside; water must enter the pen through the pen tip. Water flowing through pen in wrong direction will cause further clogging.

1. With pen removed from Recorder, fill Brush plastic syringe with water, and insert pen tip in syringe needle.

TO CLEAN IN PENS (Continued)

2. Depress syringe plunger, forcing water through pen tip and pen until pen is cleared. If necessary, soak pen in water overnight, then repeat Cleaning Procedure.

to clean ink lines

Ink lines (capillary tubes) should be rinsed periodically with water to dispose of sediment.

1. Open rear door of Recorder. Loosen screws on clamp securing reservoir from clamp. Unscrew reservoir from cover.
2. Soak reservoir in water and rinse thoroughly. Fill reservoir with water to within 1/4" of top. Screw reservoir securely into cover, and position reservoir in clamp on chassis.
3. Remove all pens from Recorder. Depress and release primer buttons on front of Recorder to pump water from reservoir through ink lines, catching water in a suitable container as it is expelled from lines.
4. When ink lines are rinsed thoroughly, lift reservoir from clamp, and unscrew reservoir from cover. Screw replacement reservoir into cover and place in clamp on chassis. Tighten clamp screws securely, and close rear door.
5. Install pens on Recorder and with front door open, depress and release primer buttons to expell water in lines and prime pens, catching water in a suitable container. When ink flows freely from all pens as primer buttons are depressed, close front door of Recorder.

precautions

1. Keep watches, chronometers, and similar instruments away from Recorder.
2. Do not drop Recorder or tap penmotors with a hammer.
3. Prevent dirt, dust, metal filings, and the like from entering penmotors.
4. If either penmotor is damaged remove from Recorder and send to factory for repairs.

Special equipment is required for magnetization and coil alignment.

lubrication (every 250 hours operation)

Remove chart paper and, with writing table pulled upward to limit, lift one side of gear cover with a screwdriver. Tilt cover and remove from Recorder. Apply lubricant sparingly. Use Stanoil # 35 or Gulfcreast "C" lubricant for wick type oilers on motor and sintered bearings in transmission; use Lubriplate (140 or APG 90 or equivalent) for exposed gears and clutches. Replace gear cover and chart paper. Lubricants may be obtained locally.

tube replacement

All tubes in the Recorder are accessible for replacement when the case is removed. No adjustment is required following replacement of tubes in the Recorder power supply. However, when a tube has been replaced in an amplifier channel, that channel must be balanced and calibrated, as described in the following:

balancing

1. Set volts/chart line controls to off position. Turn sensitivity control as far as possible in clockwise direction.
2. Turn power on an allow 15 minutes for the instrument to stabilize.
3. Using the pen bias control, center the pen on the chart.
4. Turn balance control, on the rear of the instrument, as far as possible in a clockwise direction. Rotate sensitivity control alternately left then right, at the sametime turn the balance control counterclockwise until no pen deflection is noted.
5. Using the pen bias control re-center the pen then turn the sensitivity control to X1 position.

calibration

The instrument has been calibrated at the factory so that the volts/chart line setting equals the pen deflection when the sensitivity control is in the X1 position. Should it become necessary to recalibrate the recorder, allow the unit to warm up for approximately 15 minutes then proceed as follows:

1. Loosen locking screws and remove the instrument from its case.
2. Set sensitivity switch to the X1 position.
3. Apply an accurate 0.20 volt d.c. voltage to input terminals 1 to 2.
4. Set the calibration control, located on the rear of the pen bias control, for 20 lines deflection.
5. Replace the unit in its case and fasten the locking screws.

frequency compensation

The Mark II Recorder is adjusted for optimum frequency response at the factory. Should re-adjustment become necessary, proceed as follows:

1. Connect an oscillator which covers the range from 10 to 100 cps., to terminals number 1 and number 2.

   Note: To minimize hum pick-up use shielded leads.

2. Set volts/chart line switch at 10 position and operate the instrument at a 25 mm per sec. chart speed. Use the pen bias control to center the pen on the chart paper. Set the frequency compensation control, located on the rear of the instrument, at approximately mid-position.

3. Adjust oscillator frequency to 10 cps. and output level for 10 lines of total pen deflection (peak-to-peak). If oscillator frequency is not sufficient to produce 10 lines deflection, set the volts/chart line switch to a more sensitive position until a 10 line deflection is noted. The oscillator output voltage is a reference voltage and must be held constant during the frequency compensation procedure. The volts/chart line switch and the sensitivity control must also remain unchanged.

4. At 100 cps., with the oscillator output voltage the same as in step 3, adjust the frequency compensation control as necessary to obtain a pen deflection of 10 chart lines.

FREQUENCY COMPENSATION (Continued)

5. Sweep the frequency range from 10 cps. to 100 cps. Hold oscillator output voltage constant and check for flatness of response. Adjust the frequency compensation control, if necessary, to obtain optimum response from 10 cps. to 100 cps.

trouble shooting

The chart below lists symptoms and probable causes of improper operation of the Recorder for failure of the Recorder to operate, as well as probable remedies for unsatisfactory operating conditions.

Conditions described in the chart are for a Brush Recorder Mark II, Model RD 2521 10, operating from a 60 cps. 115 volt power source. Procedures suggested in "Remedy" column may be performed by operating personnel.

Before checking trouble symptoms against chart, see that all quick connectors are securely connected to wiring boards.

GENERAL

SYMPTOM	CAUSE	REMEDY
1. Recorder does not operate; pilot lamp does not light.	a. Power cable disconnected.	a. Connect power cable.
	b. No power line voltage.	b. Connect Recorder to proper power source.
	c. Fuse open.	c. Replace fuse.
	d. Defective POWER switch.	d. Replace defective switch.

GENERAL

	SYMPTOM	CAUSE	REMEDY
2.	Recorder does not operate; pilot lamp lights.	a. Rectifier tube 6BW4 defective.	a. Replace defective tube.
		b. Cabling defective between amplifier and penmotor.	b. Repair cable.
		c. Defective 12B4A, 12AT7, or 12AX7 tube.	c. Replace defective tube.
		d. Interspeed muting switch closed or defective.	d. Depress appropriate CHART SPEED button, or replace defective switch.

AMPLIFIER SECTION

1.	Amplifier operates and can be balanced; noise or hum indicated on chart.	a. Hum balance control out of adjustment.	a. Adjust as described in Operating Instructions.
		b. Lack of shielding at amplifier input.	b. Shield input terminals.
		c. Defective 12AX7, 12AT7 or 5687 tube (cathode to heater leakage).	c. Replace defective tubes, balance and calibrate amplifier channel.
		d. Defective filter capacitor.	d. See "Power Supply" below.
		e. Unregulated plate voltage.	e. See "Power Supply" below.
2.	Amplifier operates and can be balanced; drifts excessively.	a. Power line voltage below 105v or above 125v.	a. Connector Recorder to proper power source.
		b. Defective 12AX7 or 12AT7 tubes.	b. Replace defective tubes balance and calibrate amplifier channel.
		c. +B to −B voltage varies.	c. See "Power Supply", below.
3.	Amplifier operates and can be balanced PEN BIAS control does not operate.	a. Defective 12AX7 tube.	a. Replace defective tube.
		b. Defective PEN BIAS control.	b. Replace defective control.
		c. Open resistor from arm of PEN BIAS control to −B.	c. Replace defective resistor.

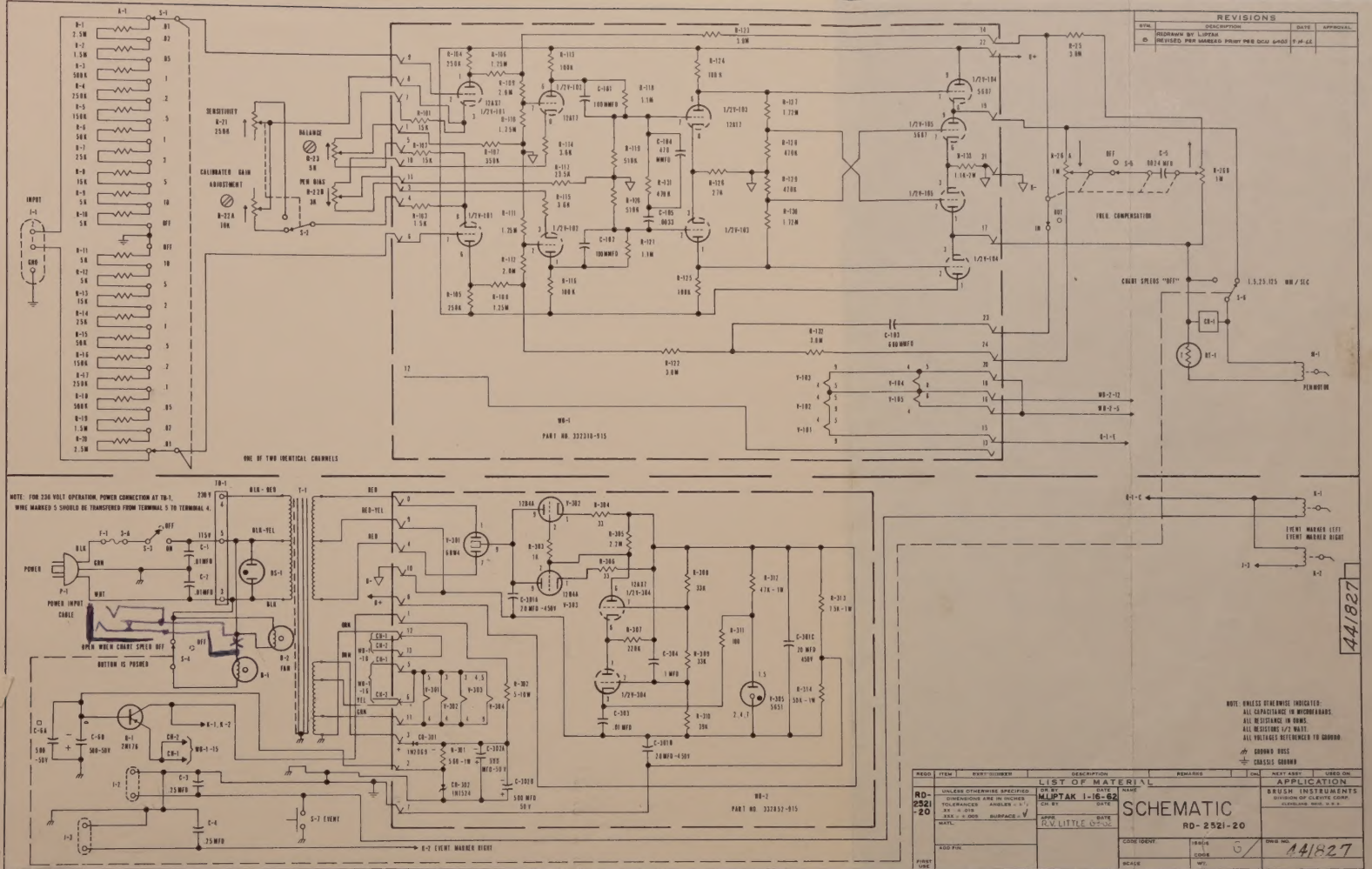
	SYMPTOM		CAUSE		REMEDY
4.	Maximum sensitivity less than 20 chart lines (mm) with SENSITIVITY control fully clockwise.	a.	Insufficient power line voltage.	a.	Connector Recorder to proper power source.
		b.	Weak 12AX7, 12AT7, 5687,6BW4, or 12B4A tube	b.	Locate and replace defective tube.
		c.	Defective resistor cathode of 12AX7 tube and calibrated gain switch on SENSITIVITY control.	c.	Replace defective resistor.
5.	Sensitivity at "XI" position of SENSITIVITY control inaccurate.	a.	Weak 12AX7, 12AT7, 5687, 6BW4, or 12B4A tube.	a.	Locate and replace defective tube.
		b.	Calibrated gain control (on rear of PEN BIAS control) improperly adjusted.	b.	Reset calibrated gain control as described under "Tube Replacement".
		c.	Defective resistor between cathod of 12AX7 tube and calibrated gain "XI" switch on SENSITIVITY control.	c.	Replace defective resistor and reset calibrated gain control as described under "Tube Replacement".
6.	Amplifier can be balanced and calibrated, but is nonlinear.	a.	Defective 12AX7,12AT7, or 5687 tubes.	a.	Replace defective tubes, balance and calibrate amplifier channel.
7.	Sensitivity incorrect at certain VOLTS/CHART LINE switch positions.	a.	Defective resistor in attenuator network.	a.	Replace defective resistor.
8.	Amplifier channel cannot be frequency compensated to penmotor.	a.	Defective resistor or capacitor in compensation network.	a.	Locate and replace defective resistor or capacitor.

SYMPTOM	CAUSE	REMEDY
RECORDER SECTION		
1. Crosstalk between penmotors.	a. Penmotor circuit grounded.	a. Locate and eliminate ground.
2. Pen continues to indicate signal when CHART SPEED "off" button is depressed.	a. Defective interspeed muting switch.	a. Repair or replace defective switch.
3. Pen cannot be primed with primer button.	a. No ink in ink reservoir. b. Clogged pen or ink system.	a. Install replacement reservoir. b. Clean pen or ink system as described in Operating Instructions.
4. Chart drive motor does not operate, POWER SWITCH INDICATOR is lighted.	a. Defective motor.	a. Replace defective motor.
5. CHART SPEED buttons will not remain engaged.	a. Broken flat spring on latching bar. b. Worn latching bar.	a. Replace broken spring. B. Replace CHART SPEED pushbutton assembly.
6. CHART SPEED button will not release.	a. Broken coil spring on pushbutton assembly.	a. Replace CHART SPEED pushbutton assembly.
7. CHART SPEED button does not select proper chart speed.	a. Inoperative transmission.	a. Return Recorder to factory service department for repair.
8. Chart does not move CHART SPEED buttons are depressed.	a. Defective gear in gear train or transmission.	a. Return Recorder to factory service department for repair.

MARK II
Model RD 2521 10
Electrical Parts List

Reference Designation	Description	Brush Part No.
B-1	Transmission Assembly	127831-PL1
B-2	Motor, Fan	121936
C-1	Capacitor	20-125905-103
C-2	Same as C-1	
C-3	Capacitor	5-130488-254
C-4	Same as C-3	
C-5	Capacitor	5-122233-242
C-6	Capacitor	232732
CR-1	Clipper	128850-2
DS-1	Indicator, Neon	126621
F-1	Fuse	102625-9
K-1	Marker Assembly, Event, L. H.	227665-910
K-2	Marker Assembly, Event, R. H.	227665-920
M-1	Penmotor Assembly, Analog	428647-920-138
Q-1	Transistor, Type 2N176	232211
R-21	Resistor, Includes S-2	127251
R-22	Resistor, Variable, Dual	127390
R-23	Resistor	19-211473-502
R-24	Same as R-22	
R-25	Resistor	1-117802-3004
R-26	Resistor	126255
R-27	Same as R-26	
RT-1	Resistor, Thermal	128196
S-1	Switch Assembly	427344-910
S-2	See R-21	
S-3	Switch, Toggle	121068
S-4	Switch, S.P.S.T.	127521
S-6	Switch, D.P.S.T.	127524
S-7	Switch, S.P.S.T.	231968
T-1	Transformer, Power	227396

Reference Designation	Description	Brush Part No.
V-1	Tube, Electronic, 12AX7	125835
V-2	Tube, Electronic, 12AT7	125833
V-3	Same as V-2	
V-4	Tube, Electronic, 5687	122828
V-5	Same as V-4	
V-301	Tube, Electronic, 6BW4	126997
V-302	Tube, Electronic, 12B4A	124390
V-303	Same as V-302	
V-304	Same as V-1	
V-305	Tube, Electronic, 5651	240853
WB-1	Board Assembly	332318-915
WB-2	Board Assembly, Power Supply	332852-915
XF-1	Holder, Fuse	119365


REVISIONS
SYM | DESCRIPTION | DATE | APPROVAL
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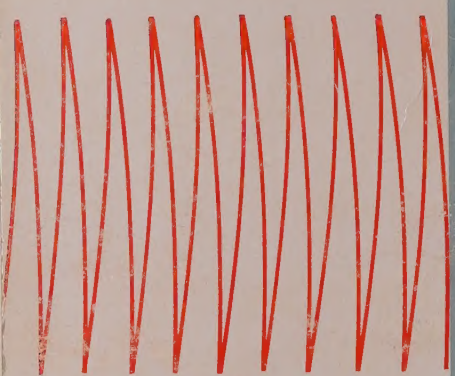
INPUT
GND
SENSITIVITY R-21 250K
BALANCE R-23 5K
CALIBRATOR GAIN ADJUSTMENT R-22A 10K
MTR BIAS R-22B 3K
S-1
ONE OF TWO IDENTICAL CHANNELS
W8-1
PART NO. 332318-915
FREQ. COMPENSATION
C-5 .0024 MFD
COUNT SPEEDS "OFF"
1.5.25.125 MM / SEC
S-6
CR-1
MT-1
M-1
PENMOTOR
W8-2-12
W8-2-5
A-1-1
NOTE: FOR 230 VOLT OPERATION, POWER CONNECTION AT TB-1 WIRE MARKED 5 SHOULD BE TRANSFERRED FROM TERMINAL 5 TO TERMINAL 4.
TB-1
T-1
POWER
P-1
POWER INPUT CABLE
OPEN WHEN CHART SPEED OFF
BUTTON IS PUSHED
S-4
S-3
F-1
S-2
B-1
B-2 FAN
MS-1
W8-2
PART NO. 332357-915
B-2 EVENT MARKER RIGHT
S-7 EVENT
A-1-C
EVENT MARKER LEFT
EVENT MARKER RIGHT
J-1
J-2
441827
NOTE: UNLESS OTHERWISE INDICATED:
ALL CAPACITANCE IN MICROFARADS
ALL RESISTANCE IN OHMS.
ALL RESISTORS 1/2 WATT.
ALL VOLTAGES REFERENCED TO GROUND
GROUND BUSS
CHASSIS GROUND
LIST OF MATERIAL
RD-2521-20
DR. BY MLIPTAK 1-16-62
CH. BY
APP. R.V. LITTLE
SCHEMATIC
RD-2521-20
APPLICATION
BRUSH INSTRUMENTS
DIVISION OF CLEVITE CORP.
CLEVELAND, OHIO, U.S.A.
CODE IDENT. 18616
SCALE
DWG NO. 441827

82308



brush INSTRUMENTS
DIVISION OF
37TH AND PERKINS CLEVITE CLEVELAND 14, OHIO

MP MASTER
MA34683